Synchrotron Metrology for Ultra-thin Films Deposited by ALD for Emerging MOS Devices

Sonal Dey, Alain Diebold
Colleges of Nanoscale Science and Engineering, State University of New York Polytechnic Institute, Albany, NY

Metal oxide semiconductor (MOS) devices with HfO_2 thin films as high-k gate dielectric material have been successfully implemented at the 45 nm technology node and beyond. The continual “miniaturization” of MOS devices requires development of high-k dielectric ultra-thin films (< 5 nm) that can further reduce the equivalent oxide thickness (EOT) and also minimize the gate leakage current. Density functional theory predicts that the value of the dielectric constant for HfO_2 based materials is dependent on the nature of the crystalline phase, some of which are metastable in nature. Our goal is to (1) increase the dielectric constant and (2) stabilize the metastable crystalline phases of HfO_2 based metal oxide films by compositional alloying with other metal oxides, as for example, oxides of Zr, Al and Ti. We have used atomic layer deposition (ALD) technique for growing these highly conformal ultra-thin films. In this talk, some of the recent findings and characterization results will be discussed where we have combined various synchrotron based x-ray techniques, such as grazing incident x-ray diffraction (both in and out of plane), x-ray absorption spectroscopy and x-ray photoelectron spectroscopy (XPS), with other lab based techniques, such as spectroscopic ellipsometry and lab-based XPS.